Progress Energy

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January 31, 2013

The Honorable Jocelyn G. Boyd
Chief Clerk/Administrator
Public Service Commission of South Carolina
101 Executive Center Drive, Suite 100
Columbia, SC 29210

  Re: **Docket No. 2010-41-E**

Dear Mrs. Boyd:

   Pursuant to the Commission's February 10, 2010 directive in Docket No. 2010-41-E, Progress Energy Carolinas, Inc. submits the attached report summarizing the 2011 program year evaluation, measurement and verification (EM&V) results for its Appliance Recycling Program. Progress Energy Carolinas, Inc. is currently evaluating the recommendations provided in the EM&V report.

         Very Truly Yours,

         Timika Shafeek-Horton
         Deputy General Counsel

Attachment
cc: Courtney Edwards

Progress Energy Service Company, LLC
P. O. Box 1551
Raleigh, NC 27602

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2011 EM&V Report for the
Appliance Recycling Program

Presented to
Progress Energy Carolinas

Prepared by
The Cadmus Group
with Navigant Consulting

January 2013

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The Progress Energy Carolinas ("PEC") Appliance Recycling Program ("ARP") offers residential customers in North and South Carolina a $50 incentive and free pickup service for recycling operable refrigerators and standalone freezers. Appliance Recycling Centers of America ("ARCA") acted as program implementer for program year 2011 ("PY11"). In total, 7,542 appliances—5,879 refrigerators and 1,663 freezers—were recycled during PY11.

1.1 Evaluation Objectives and Methodology

Navigant Consulting, Inc., (Navigant) and The Cadmus Group, Inc., (Cadmus) evaluated the PY11 ARP, focusing on two primary objectives:

- Determining gross and net energy (kWh) and peak demand (kW) savings at the measure and program levels; and

- Assessing the program's effectiveness, as currently designed, and identifying possible programmatic improvements.

The evaluation tasks outlined in Table ES-1, below, sought to inform these objectives.

Table ES-1. Summary of PY11 Evaluation Tasks

Task	Impact	Process	Details
Program Database Review	X		Ensured appropriate data were collected to inform the evaluation, particularly the *in situ*, metering-based, energy-savings regression model.
Participant Surveys (n=198)	X	X	Used to verify participation, calculate a net-to-gross (NTG) ratio, and assess program implementation.
Nonparticipant Surveys (n=17)	X	X	Used to determine NTG, assess program awareness, and learn why some PEC customers opted to discard their appliances outside the program.
Stakeholder Interviews (n=3)		X	Provided insight into program design and delivery as well as potential refinements or improvements to the current program. Stakeholders included the program manager at PEC and two implementers at ARCA.
Gross Savings Model	X		Used to determine gross energy savings for specific appliances recycled by PEC in PY11, using a database of *in situ* metering results from four other recent appliance recycling evaluations.
Facility Audits	X		Used to independently assess unit ages and physical characteristics on-site at ARCA recycling facility, compared to ARCA tracking database.

1.2 Uniform Methods Project

In 2011, the Department of Energy (DOE) launched the Uniform Methods Project (UMP) with the goal of "strengthen[ing] the credibility of energy savings determinations by improving EM&V, increasing the consistency and transparency of how energy savings are determined."[1] UMP identified seven common residential and commercial demand-side management measures and enlisted a set of subject matter experts to draft evaluation protocols for each. Refrigerator recycling was one of the seven identified measures. The DOE recruited Cadmus to manage the UMP process, as well as be the lead author for the refrigerator recycling protocol.

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[1] http://www.nrel.gov/docs/fy13osti/54945.pdf

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Through a collaborative process that involved reviews by a technical advisory group (TAG) and a steering committee (SC), as well as a public review and response process, UMP resulted in a set of protocols (including one for appliance recycling) that capture the collective consensus of the evaluation community. Each protocol establishes broadly accepted best practices for the evaluation of these seven measures, including the identification and explanation of key parameters, data sources, and gross and net-related algorithms.

Although the seven UMP protocols will not be publicly available until later in 2013, this PY11 ARP evaluation report follows the methodology outlined in the recently finalized refrigerator recycling protocol. Since Cadmus was the lead author of this protocol, the methodology largely mirrors Cadmus' previous recycling evaluations, including Progress Energy's PY10 ARP evaluation. It should be noted that input from the broader evaluation community through the SC, TAG, and public review process has caused Cadmus to make several meaningful changes to its previous methodology and these have been applied to the PY11 evaluation.

We have summarized the four most notable changes below.

- *Prospective Part-Use*. UMP dictates that part-use be assessed based on how the recycled appliance was likely to have been used had it not been recycled, not on how it was previously used. For example, if a primary refrigerator would have become a secondary refrigerator independent of the program, its part-use should reflect the average usage of secondary refrigerators.

- *Induced Replacement*. UMP states that replacement is an unavoidable and naturally occurring aspect of the appliance market. As a result, program savings should not be estimated as the difference in energy consumption between the recycled appliance and the appliance that replaces it. However, the exception to this rule is when recycling programs induce a replacement that otherwise would not have occurred. In such a scenario, savings should be assessed as the difference in energy consumption between the recycled appliance and its replacement, rather than the energy consumption of the recycled appliance.

- *Secondary Market Impacts*. UMP takes a grid-level approach to estimating net program savings. Therefore, the program's impact on the used appliance market must be considered. Does the program actually reduce the total number of older appliances operating on the grid or do the would-be recipients of appliances recycled through the program find an alternate unit instead (since the appliance recycled by the program was unavailable)?

- *Regression Model Specification*. UMP stipulates a model specification for estimating each appliance's annual energy consumption when it is not feasible to use utility-specific in situ metering and modeling. The UMP model reflects the availability of more winter metering data and the need to create a more universal and weather symmetrical model (i.e., one that accounts for the effects of heating and cooling degree days).

More information about UMP is available on the DOE's Website.[2]

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[2] http://www1.eere.energy.gov/office_eere/de_ump.html

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1.3 Evaluation Findings

Table ES-2 compares the verified per-unit energy savings determined through this evaluation to PEC's PY11 deemed savings, which were based on the findings of the PY10 evaluation. As shown, refrigerator savings were lower than the deemed value, while freezer savings were slightly higher. The disparity in verified savings for refrigerators was driven by three main factors:

- Changes to the regression model used to estimate average unit energy consumption (UEC) that included additional appliances in the metering database and changes to the model specification
- A decline in the part-use factor from PY10 largely as a result of the application of prospective part-use.
- Changes in the characteristics of recycled appliances in PY11 (compared to PY10)

The increase in verified savings for freezers was driven in most part by changes in the regression model similar to those for refrigerators. Full details regarding each of the impacts outlined above are included in the gross savings section below.

Table ES-2. Comparison of Deemed and Verified Per-Unit Gross Savings

Appliance	Per-Unit Gross Energy Savings (kWh/Year)		Per-Unit Gross Demand Reduction (kW)		Realization Rate
	Deemed	Verified	Deemed	Verified	
Refrigerators	1,073	929	0.122	0.106	87%
Freezers	668	749	0.076	0.085	112%

Using surveys with PY11 participants and nonparticipants, as well as market actor interviews conducted in PY10, the evaluation team determined PY11 net impacts (Table ES- 3). The methodological changes necessitated by UMP had a greater impact on net savings than gross savings. Specifically, the inclusion of induced replacement and secondary market impacts estimates in PY11 resulted in a decrease in net savings (neither estimates were included in the PY10 evaluation). The difference in NTG ratios between PY10 and PY11 are shown below in Table ES- 4.

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Table ES- 3. PY11 Verified Gross and Net Program Savings

Appliance	Total Program Gross Savings (MWh/Year)	Total Program Gross Demand Reduction (MW/Year)	NTG	Total Program Net Savings (MWh/Year)	Total Program Net Demand Reduction (MW/Year)**
Refrigerator	5,460	0.62	0.57	3,130	0.36
Freezer	1,245	0.14	0.62	774	0.09
Total	6,705	0.77	0.58	3,904	0.45

*Precision was calculated to reflect the combined effect of error generated by the regression model, part-use estimate, and participant and nonparticipant NTG.
**This evaluation assumes flat refrigerator and freezer load shapes. As a result, all demand reduction values provided are applicable for assessing summer and winter coincident peak savings.

Table ES- 4. Comparison of Deemed and Verified NTG

Appliance	Evaluated NTG		Difference
	PY10	PY11	
Refrigerators	0.72	0.57	- 0.15
Freezers	0.74	0.62	- 0.12

A comparison of the verified net program savings to PEC's PY11 deemed net savings is provided in Table ES- 5. Program net impacts declined substantially from PY10 with a decrease in NTG of 15% and 12% for refrigerators and freezers, respectively. The majority of the change is due to a change in methodology: primarily the inclusion of secondary market impacts and induced replacement. Full details of the change in methodology are included below in Section 4.

Table ES- 5. Comparison of PY11 PEC Reported and Verified Net Program Savings

Appliance	Program Recycled Appliances	Deemed Per-Unit Net Savings(kWh)	Total Program Reported Net Savings (kWh/Year)	Verified Per-Unit Net Savings (kWh)	Total Program Verified Net Savings (kWh/Year)	Realization Rate
Refrigerator	5,879	778	4,571,225	531	3,130,000	68%
Freezer	1,663	495	822,749	459	774,000	94%
Total	7,542		5,393,974		3,904,000	72%

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1.4 Conclusions

The evaluation team offers the following impact and process conclusions regarding PY11:

Impact

- The program recycled 7,542 units in PY11 (an increase of approximately 16% from PY10), generating 3,904 MWh in net energy savings, (down approximately 15% from PY10).

- ARCA is accurately capturing the ages of participating refrigerators and freezers.

- The refrigerator part-use factor (indicating the portion of the year the average refrigerator would have been operated in the absence of the program) was lower in PY11 (0.90) than PY10 (0.98). Some of the decline is due to the application of prospective part-use outlined in the UMP protocol (rather than the retrospective assessment used in PY10). While subtle methodological differences exist between PY10 and PY11, the primary driver of the lower PY11 part-use value for refrigerators is the fact that fewer survey respondents indicated their appliances were in use year round in PY11 (88%, compared to 97% in PY10). However, the PY11 value is more in line with refrigerator part-use factors found as part of other evaluations. Conversely, the part-use factor for freezers was higher in PY11 (0.93) than PY10 (0.84) and, again, generally consistent with values found through evaluations of similarly aged programs.

- Verified gross per-unit savings for refrigerators (929kWh) were 13% lower than the program's deemed value (1,073 kWh). The disparity was driven largely by the decrease in the part-use factor for refrigerators noted above. Also, the verified gross per-unit savings for freezers (749 kWh) was 12% higher than the program's deemed savings value (668 kWh).

- NTG ratios for both appliance types declined substantially in PY11 (0.57 and 0.62, as opposed to 0.72 and 0.74 in PY10, for refrigerators and freezers, respectively) largely due to changes in NTG methodology between PY10 and PY11 resulting from the UMP protocol.

Process

- There were no major changes in program design in PY11.

- All stakeholders indicated the program operates smoothly, with few complaints and a lower-than-anticipated cancellation rate. Stakeholder perceptions were validated by the high levels of satisfaction reported by surveyed participants (88%) which was comparable to PY10.

- Bill inserts continued to be the most successful marketing tactic in PY11 (cited by 62% of participants as the source of program awareness). Interviewed stakeholders also noted word-of-mouth was becoming an increasing generator of participation, which indicates the program has gained traction within the service territory and been well received by previous participants.

- PY11 marketing was described, by the PEC program manager, as a "learning year" as the program became increasingly aware of how its marketing efforts impacted the program – specifically, how to target customer segments most likely to have older, inefficient units. Marketing segmentation was attempted to reach specific types of

customers, namely established households that are more likely to have older appliances that generate greater savings. The average age for both refrigerators and freezers increased slightly in PY11, both by approximately one year. Since appliance recycling programs typically collected increasingly younger units as they mature, the observed increase in age could be in part due to the marketing efforts.

1.5 Recommendations

Based on these conclusions, the evaluation team offers the following recommendations:

- Continue to employ a myriad of marketing approaches, evaluating the individual and collective effectiveness of each approach on increasing participation and soliciting participation of the targeted customer segments. This could be done by cross checking the average age in the program tracking database by ZIP code with the targeted marketing efforts aimed at identifying areas of PEC's service territory believed to be most likely to own and operate older secondary appliances.

- Work more collaboratively with ARCA to develop a marketing plan that leverages ARCA's extensive experience marketing appliance recycling programs across North America for the purpose of achieving greater market penetration as the program matures.

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2.1 The Appliance Recycling Program

The Progress Energy Carolinas ("PEC") Appliance Recycling Program[3] ("ARP") provides residential customers in North and South Carolina with free pickup and a $50 incentive for allowing Appliance Recycling Centers of America, Inc. ("ARCA") — PEC's ARP implementation contractor—to collect, de-manufacture, and recycle customers' less efficient but operable refrigerators and/or standalone freezers, permanently removing the units from service. Advertising focuses specifically on secondary units but the program also allows recycling of primary units as well. Qualifying appliances must be between 10 and 30 cubic feet and be plugged in, cooling, and empty at the time of pickup.

The program seeks to achieve savings by permanently removing less efficient refrigerators and freezers from participating homes and to prevent older appliances from being transferred to other PEC homes, where they would continue to operate inefficiently. In addition to energy savings and demand reductions generated, the program recycles all participating appliances in an environmentally safe manner.[4]

2.2 Reported Program Participation and Expected Savings

According to the program database provided by ARCA, the program recycled 7,542 participating appliances in PY11. Table 1 summarizes participation by appliance type.

Table 1. PY11 ARP Participation (by Appliance Type)

Appliance Type	Program Recycled Appliances	Percent of Total
Refrigerator	5,879	78%
Freezer	1,663	22%
Total	7,542	100%

As shown in Figure 1, the program quickly ramped up going into the spring of 2011 with the peaks in March, August, and December. The spring peak coincides with a "spring cleaning" advertising effort consisting of bill inserts and direct mail.

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[3] Ref. Docket No. E-2, SUB 970 in North Carolina; and Docket No. 2010-41-E-Order No. 2010-146 in South Carolina.
[4] Oils, PCBs, mercury, and CFC-11 foam are properly disposed of; and CFC-12, HFC-134a, plastic, glass, steel, and aluminum are recycled as part of ARCA's demanufacturing process.

Figure 1. Program Participation by Month
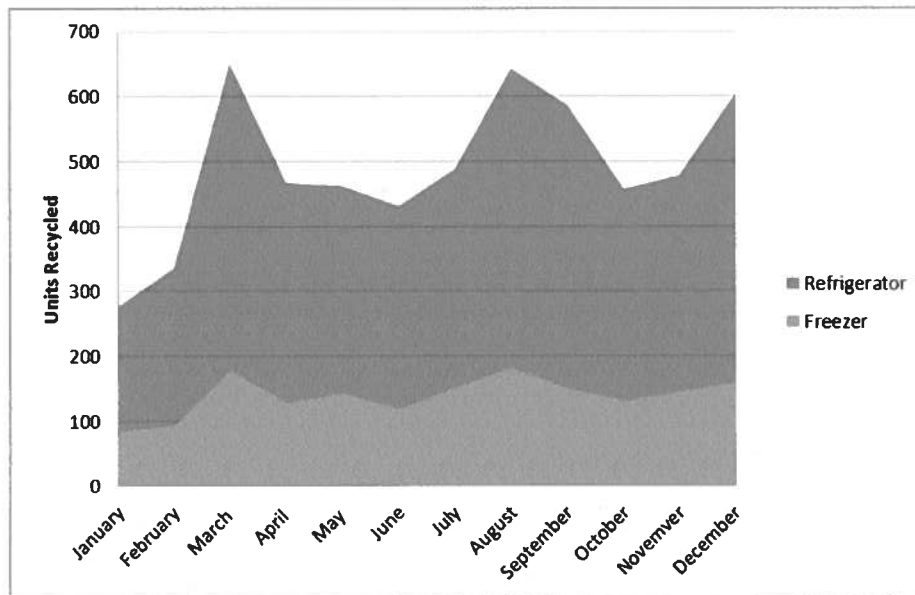
The following figures provide a brief overview of PY11 recycled appliances' key characteristics. A detailed comparison of the appliance characteristics in PY10 and PY11 is provided later in Table 8.

The distribution of refrigerator configurations remained largely unchanged between PY10 and PY11 with a slight increase in the proportion of top freezer units (67% to 70%) and a slight decline in the proportion of single door units (7% to 3%) while the distribution for freezers remained the same. This shift in configurations is common as programs mature.

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Figure 2. Refrigerator Configuration
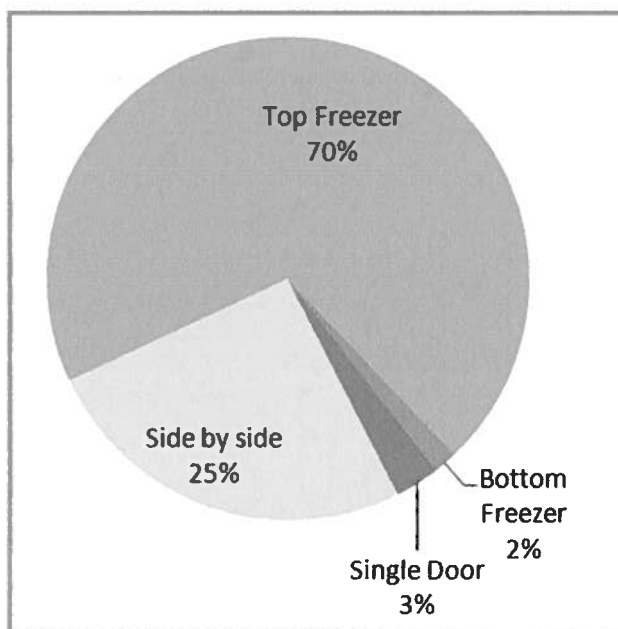
Figure 3. Freezer Configuration

The average age of participating refrigerators and freezers decreased slightly in PY11; refrigerators from 15.7 to 15.0, and freezers from 20.7 to 19.6 years old. Again, it is common for programs to recycle increasingly younger appliances as a program matures.

Figure 4. Distribution of Refrigerator Ages
(Years Old, Mean=15.0)

Figure 5. Distribution of Freezer Ages
(Years Old, Mean=19.6)

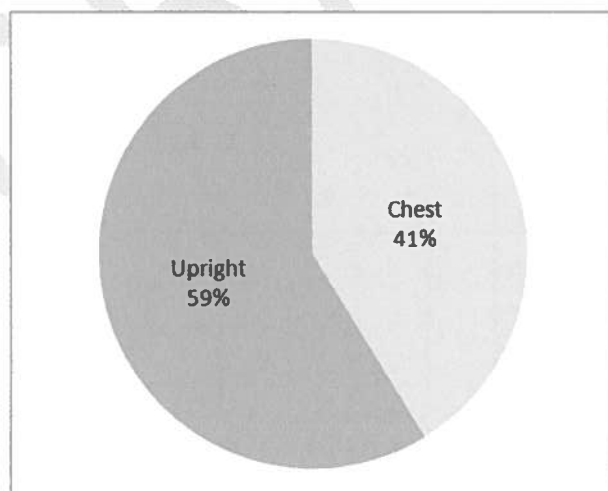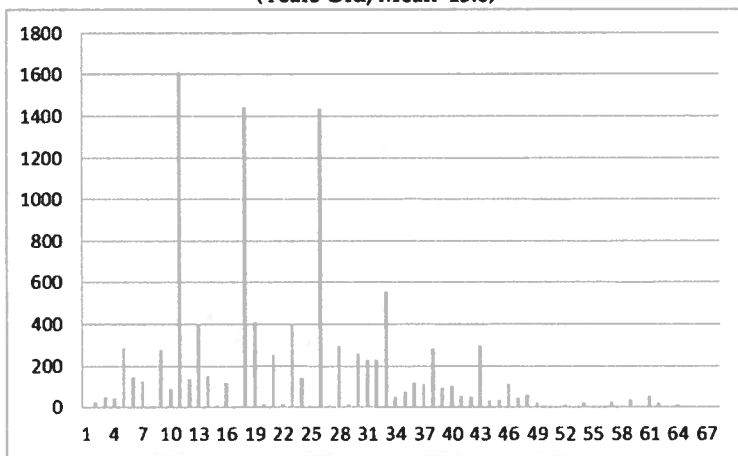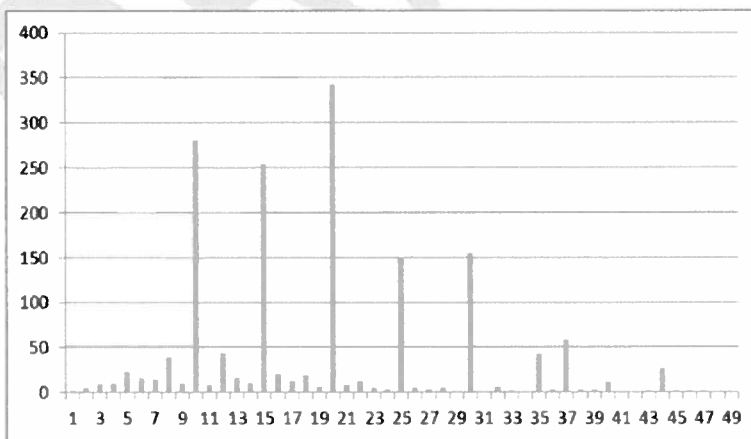NAVIGANT

The average age of participating refrigerators and freezers decreased slightly in PY11; refrigerators from 15.7 to 15.0, and freezers from 20.7 to 19.6 years old. Again, it is common for programs to recycle increasingly younger appliances as a program matures.

Figure 4 and Figure 5 show similar spikes in ages clustered around five year increments as in PY10. In PY10, these peaks were – in part – the basis for our recommendation to independently assess unit ages through a facility audit (for the purpose of verifying ARCA's tracking database). Information about the result of our assessment is provided in Section 4.5. As detailed in section 4.5, our independent assessment found that ARCA is accurately determining the age of participating appliances to the greatest extent possible. As such, the continued presence of these spikes in PY11 speaks to the generalization required when the year of manufacture is not explicitly available on the unit (which is common) and not inaccuracies on the part of the implementer.

2.3 Evaluation Objectives

The PY11 evaluation of ARP conducted by Navigant Consulting, Inc., (Navigant) and The Cadmus Group, Inc., (Cadmus) focused on two primary objectives:

- Determining gross and net energy (kWh) and peak demand (kW) savings at the measure and program levels; and

- Assessing the program's effectiveness, as currently designed, and identifying possible programmatic improvements.

The following chapters describe the evaluation team's work towards these objectives, along with our key findings.

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Section 3. Evaluation Methods

The overarching methodology used to evaluate ARP in PY11 is similar to that used in PY10. As in PY10, the program database served as a starting point for understanding the program's extent and participation as well as for specific information collected regarding each recycled appliance. The tasks undertaken in the PY11 evaluation repeated some tasks undertaken in PY10 (participant and nonparticipant surveys, stakeholder interviews) and included an additional task (facility audits).

Following evaluation plan development, the evaluation team conducted surveys with 198 program participants and analyzed *in situ* metering data collected as part of five recent appliance recycling evaluations for other utilities. Using data collected through these activities and data provided by ARCA in the PY11 program database, the team determined gross and net energy savings. These savings were then compared to PEC's reported savings for the program based upon each appliance's per-unit (deemed) savings estimates (which were based on the results of the PY10 evaluation). The collective findings allowed calculation of total program net impacts and recommendations for continued program improvements.

Figure 6, below, outlines this general process.

Figure 6. ARP Evaluation Approach
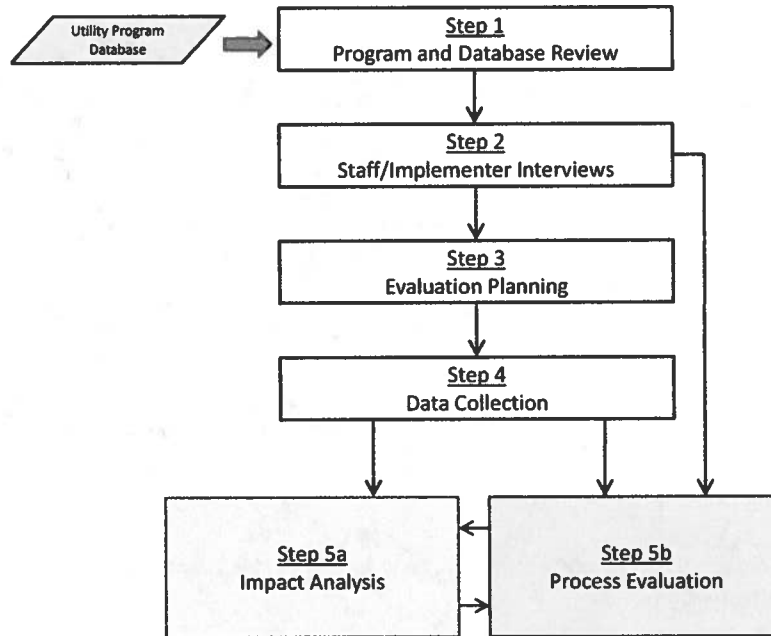
3.1 Step 1: Program and Database Review

The team reviewed the database to verify that all information needed to conduct the impact analysis—as well as to develop a participant survey sample—had been provided. The comprehensive database included all critical data fields relevant to the evaluation.

3.2 Step 2: Staff/Implementer Interviews

Our team interviewed two ARCA staff and PEC's ARP managers to understanding how the program evolved in PY11. Discussion topics included the following:

- How has program design changed since launch?
- What type of impact did these changes have?
- What marketing approaches have been used, and what were the results?
- What does the future of the program look like?

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3.3 Step 3: Evaluation Planning

In January 2011, the evaluation plan was finalized, grounded in our understanding of the program via the PY10 evaluation. The evaluation plan identified the six tasks summarized in Table 2.

Table 2. Summary of PY11 Evaluation Tasks

Task	Impact	Process	Details
Program Database Review	X		Ensured collection of appropriate data to inform the evaluation, particularly the *in situ*, metering-based, energy-savings regression model.
Participant Survey (n=198)	X	X	Used to verify participation, calculate a net-to-gross (NTG) ratio, and assess program implementation.
Nonparticipant Survey (n=17)	X	X	Used to determine NTG, assess program awareness, and learn why some PEC customers opted to discard their appliances outside the program.
Stakeholder Interviews (n=3)		X	Provided insight into program design and delivery as well as potential refinements or improvements to the current program. Stakeholders include the program manager at PEC and two implementers at ARCA.
Gross Savings Model	X		Used to determine gross energy savings for specific appliances recycled by PEC in PY11, using a database of *in situ* metering results from four other recent appliance recycling evaluations.
Facility Audit	X		Used to independently assess unit ages and physical characteristics on-site at ARCA recycling facility compared to ARCA tracking database.

3.4 Step 4: Data Collection

This section briefly describes the data collection process for the six tasks listed in Table 2. The next chapter provides more detail regarding each task, including findings.

Program Database Review

At the evaluation's outset, the team requested a copy of the program database to become familiar with the program to ensure necessary data were available; copies were also requested after the end of PY11. As noted, databases were complete and comprehensive; containing all information required to model savings and successfully evaluate the program.

Participant Survey

In July 2012, surveys were conducted with 198 randomly selected participants. Of the 198 participants surveyed, 152 recycled refrigerators, and 46 recycled freezers. The PY11 participant sample yielded estimates of NTG and part-use factors at 90 percent confidence and 8 percent precision for refrigerators, and 90 percent confidence and 10 percent precision for freezers.[5]

Participant survey questions were intended to:

- Verify program participation, involvement in decision-making processes, and appliance removal;

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[5] These confidence intervals refer to errors of NTG and part-use estimates, not final net savings, which combines the errors associated with additional regression outputs.

- Determine how participants learned about the program;

- Determine whether participants had been using the recycled appliance;

- Determine what alternative disposal methods participants used independently of program participation; and

- Evaluate program satisfaction.

The appendices to this document provide a copy of the participant survey instrument. The participant survey used in PY11 was substantively unchanged from PY10.

Nonparticipant Survey

In May 2012, a general population survey was conducted with 1,355 randomly selected PEC customers. The survey was designed to inform multiple programs for the overall residential evaluation, including the identification of and interviews with ARP nonparticipants (defined as customers that discarded an operable refrigerator and/or freezer outside the program in 2011). Of the 1,355 customers surveyed, only 17 were identified as appliance recycling nonparticipants. Similar to PY10, the evaluation team had anticipated a larger sample. To maximize confidence of the nonparticipant comparison, the 17 completed surveys were combined with the 30 nonparticipant surveys completed in PY10 for a total of 47 nonparticipants.[6]

Surveys with nonparticipants provide valuable insight into what happens to older, operable appliances in the absence of the program. As participant survey respondents are often subject to socially desirable response bias (in the case of an appliance recycling program, exaggerating the likelihood that they would have recycled their appliances even without the program's assistance), using both participant and nonparticipant responses to determine free ridership increases the reliability of verified NTG values and follows ARP evaluation best practice. There is no reason to believe that combining the nonparticipant surveys from PY10 and PY11 would in any way bias the results since it is unlikely customers would have discarded their operable appliances outside of the program differently from one program year to the next.

Nonparticipant survey questions were intended to:

- Determine whether nonparticipants were aware of the program; and

- Determine how customers actually disposed of operable refrigerators and freezers independent of program participation.

The appendices to this document provide a copy of the nonparticipant ARP module included in the general population survey. As with the participant survey, the PY11 nonparticipant survey is substantively unchanged from PY10.

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[6] Assuming an equal number of refrigerators stop being used each year (either due to customer decision or failure), an expected useful life (EUL) of 20 years means approximately 1 in 20 households (5 percent) discard a refrigerator annually. Since the survey also asked about discarded freezers, the odds of identifying a household discarding one of the two program appliances doubles (generously assuming all contacted households have a standalone freezer). However, the identification of nonparticipants is further complicated since customers must be discarding an operable (therefore program-eligible) appliance in order to be surveyed. This critical detail (since inoperable units are discarded very differently than operable units) reduces the chances of identifying an ARP nonparticipant.

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Stakeholder Interviews

As shown in Figure 6, interviews with program stakeholders informed the work's overall scope and the process evaluation. Specifically, the EM&V team interviewed the PEC program manager and two ARCA program managers, who are responsible for program design and implementation, with all interviews conducted over the phone.

The stakeholder interview guide focused on key program management issues, including, but not limited to, the following:

- Changes since PY10;
- Process flow;
- Marketing tactics and successes; and
- Program strengths and areas for improvement.

Gross Savings Model

Similar to the methodology used in PY10, the evaluation team utilized a multivariate regression model to determine gross unit energy consumption (UEC) of retired refrigerators and freezers. This model used an aggregated *in situ* metering dataset, composed of data for 564 appliances metered as part of five evaluations in California and Michigan.[7] However, the size and composition of the aggregated *in situ* metering dataset changed between PY10 and PY11 due to the availability of new metering data - another wave of winter metering data from Michigan, which was collected on behalf of Consumers Energy[8]. The addition of the Consumers Energy winter data doubled the number of winter observations allowing the inclusion of heating degree days (HDD) as an explanatory variable in the UMP UEC model specification. The addition of the HDD term enhances the model's ability to accurately estimate consumption for appliance recycling programs that experience a wider range of weather.

Collectively, the metering dataset offered a wide distribution of appliance ages, sizes, configurations, usage scenarios (primary or secondary), and climate conditions. The dataset's diverse nature make it an ideal secondary data source for determining appliance recycling energy savings when utility-specific *in situ* metering was not possible as with PEC.

Table 3 details the final model specification used to determine the annual UEC of refrigerators recycled through ARP. Again, the model specification used for the PY11 evaluation differs slightly from PY10 and aligns with UMP.

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[7] Southern California Edison, Pacific Gas & Electric, San Diego Gas & Electric, DTE Energy, and Consumers Energy.
[8] Only the first set of publically available winter data (from a DTE Energy evaluation) informed the PY10 evaluation.

Table 3. Refrigerator UEC Regression Model
(Dependent Variable = Average Daily kWh)

Independent Variable	Coefficient	Standard Error	p-value
Intercept	0.5822	0.60	0.33
Age (years)	0.0269	0.02	0.08
Dummy: Unit Manufactured pre-1990	1.0548	0.21	<.0001
Size (ft.3)	0.0673	0.03	0.02
Dummy: Single Door	-1.9767	0.42	<.0001
Dummy: Side-by-Side	1.0706	0.26	<.0001
Dummy: Primary Appliance	0.6046	0.22	0.01
Interaction: HDD x Dummy: in Unconditioned Space	-0.0447	0.02	0.03
Interaction: CDD x Dummy: in Unconditioned Space	0.0200	0.02	0.33

Refrigerator UEC model results implied the following:

- Units manufactured prior to the 1990 National Appliance Energy Conservation Act (NAECA) consumed more energy (approximately 1.05 daily kWh, or 383 kWh annually).

- Larger refrigerators consumed more energy.

- Single door units consumed less energy, as these units typically did not have full freezers.

- Side-by-side refrigerators experienced higher consumption due to greater exposure to outside air when opened and because of through-door features common in these units.

- Primary appliances had higher consumption due to increased usage.

- Refrigerators in unconditioned spaces in warmer climates consumed more energy.

- Refrigerators in unconditioned spaces in cooler climates consumed less energy.

Table 4 details the final model specification used to determine the annual UEC of freezers recycled through ARP. This model is not included in UMP (which was specific to refrigerators) but was created with a parallel specification to the refrigerator UMP UEC model.

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Table 4. Freezer UEC Regression Model
(Dependent Variable = Average Daily kWh)

Independent Variable	Coefficient	Standard Error	p-value
Intercept	-0.8918	0.85	0.30
Age (years)	0.0384	0.01	0.01
Dummy: Unit Manufactured Pre-1990	0.6952	0.31	0.03
Size (ft.3)	0.1287	0.04	0.00
Dummy: Chest Freezer	0.3503	0.27	0.20
Interaction: HDD x Dummy: in Unconditioned Space	-0.0313	0.02	0.05
Interaction: CDD x Dummy: in Unconditioned Space	0.0695	0.04	0.06

Freezer UEC model results implied the following:

- Older freezers had higher consumption due to year-by-year degradation and vintage.

- Freezers manufactured before the 1990 NAECA standard consumed more energy.

- Larger freezers consumed more energy.

- Chest freezers consumed less energy than upright units, due to reduced heat infiltration from door openings with these units.

- Freezers in unconditioned spaces in warmer climates consumed more energy.

- Freezers in unconditioned spaces in cooler climates consumed less energy.

The following chapter details the application of the above, appliance-specific UEC models to PEC's PY11 program data to determine per-unit and total program savings.

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Section 4. Program Impacts

This chapter details gross and net verified program impacts, both on a per-unit basis and for the program overall. The following program impacts are organized into two major sections.

Gross impacts include estimates of:

- Per-unit energy consumption through the in situ-metering based regression modeling (Section 4.1)
- Part-use factor, which accounts for units that are not in use for the entire year (Section 4.2)
- Average gross per-unit energy savings using both of the factors listed above (Section 4.3)

Gross impact also includes discussion of replacement (Section 4.4) and the evaluation team's facility audit, which verified the program's data collection procedures (Section 4.5).

Net impacts include estimates of:

- Free ridership (Section 4.8) and the program's secondary market impacts (Section 4.9)
- Induced replacement, which accounts for the proportion of participants reporting that they purchased a replacement unit due to the program (Section 4.10)
- Spillover (Section 4.11)
- Average net per-unit energy savings, and total program net savings, using both of the factors listed above (Section 4.12)

All of the above net impacts are informed by the participant and nonparticipant surveys, as well as market actor data gathered as part of the previous evaluation.

The evaluation team determined the 2011 program impacts as shown in Table 5. Again, the adoption of the UMP protocol led to methodological changes for PY11.

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Table 5. PY11 Verified Gross and Net Program Savings

Appliance	Total Program Gross Savings (MWh/Year)	Total Program Gross Demand Reduction (MW/Year)*	NTG**	Total Program Net Savings (MWh/Year)	Total Program Net Demand Reduction (MW/Year)*
Refrigerator	5,460	0.62	0.57	3,130	0.36
Freezer	1,245	0.14	0.62	774	0.09
Total	**6,705**	**0.77**	**0.58**	**3,904**	**0.45**

This evaluation assumes flat refrigerator and freezer load shapes. As a result, all demand reduction values provided are applicable for assessing summer and winter coincident peak savings.
**The Net-to-Gross methodology is detailed in Section 4.7*

4.1 Per-Unit Gross Savings

After specifying the final regression models, the evaluation team analyzed the corresponding characteristics (independent variables) for participating appliances (as captured in the ARCA program database). Table 6 summarizes program averages or proportions for each independent variable.

Table 6. PY11 PEC ARP Explanatory Variables and Mean Values[9]

Appliance	Variable	Mean Value PY11	Model Coefficient
Refrigerator	Intercept	1	0.5822
	Age (years)	15.04	0.0269
	Dummy: Unit Manufactured pre-1990	0.13	1.0548
	Size (ft.3)	18.91	0.0673
	Dummy: Single Door	0.03	-1.9767
	Dummy: Side-by-Side	0.26	1.0706
	Dummy: Primary Appliance	0.52	0.6046
	Interaction: HDD x Dummy: in Garage	2.96	-0.0447
	Interaction: CDD x Dummy: in Garage	1.33	0.0200
Freezer	Intercept	1	-0.8918
	Age (years)	19.61	0.0384
	Dummy: Unit Manufactured Pre-1990	0.31	0.6952
	Size (ft.3)	15.41	0.1287
	Dummy: Chest Freezer	0.41	0.3503
	Interaction: HDD x Dummy: in Garage	4.16	-0.0313
	Interaction: CDD x Dummy: in Garage	1.87	0.0695

To determine annual per-unit energy consumption using UEC models and PY11 PEC tracking data, the evaluation team applied average participant refrigerator and freezer characteristics to regression model coefficients to determine average

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[9] CDDs and HDDs derive from the weighted average CDDs and HDDs from TMY3 data for weather stations mapped to participating appliance zip codes. TMY3 is a typical meteorological year, using median daily values for a variety of weather data collected from 1991–2005.

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daily and annual UEC. This approach ensured the resulting UEC was based on specific units recycled through PEC's program in PY11, and not simply a point estimate from a secondary data source.

Table 7 provides the annual UEC for refrigerators and freezers recycled by PEC in PY11.

Table 7. Annual UEC—PY11

Appliance	Average Per-Unit Annual Energy Consumption (kWh/Year)	Average Per-Unit Demand (kW)*	Precision at 90% Confidence**
Refrigerators	1,032	0.118	± 10.1%
Freezers***	805	0.092	± 23.7%

*Demand calculated using a coincidence factor of 100%, reflecting a fully diversified load.
**Precision reflects the error generated by the regression model.
*** Precision for freezers was not as great as for refrigerators due to the smaller size of the sample of metered appliances (58 freezers compared to 506 refrigerators)

The average UEC for refrigerators declined by 65 kWh in PY11 (1,097 in PY10). The change is due to two factors.

First, the regression model specification changed in order to be consistent with the UMP refrigerator recycling protocol. This makes direct comparison between the two years more complicated. The most notable difference was the introduction of the HDD term, which accounts for the effect of cooler weather on units kept in unconditioned spaces (previously the model included only warm weather effects). Units kept in unconditioned spaces when the weather is cooler means the units do not have to use as much electricity to maintain cooler internal temperatures. The inclusion of the HDD term accounts for a decrease of 0.13 daily kWh, or roughly 48 kWh annually for applicable units.

Second, while the characteristics of the refrigerators recycled in PY11 were roughly similar, overall, to those recycled in PY10 there were some changes in the characteristics that decreased the average consumption. Specifically, PY11 units were slightly younger on average, fewer were manufactured prior to the 1990 NAECA standard, and there were slightly fewer primary refrigerators (which are accessed more often and therefore use more energy to maintain their internal temperature).

A direct comparison of average values for PY10 and PY11 for all model variables is provided in Table 8 below.

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Table 8. Comparison of PY10 and PY11 Mean Values

Appliance	Variable	Mean Value PY11	Mean Value PY10
Refrigerator	Age (years)	15.04	15.72
	Dummy: Unit Manufactured pre-1990	0.13	0.17
	Size (ft.3)	18.91	18.55
	Dummy: Single Door	0.03	0.07
	Dummy: Side-by-Side	0.26	0.24
	Dummy: Primary Appliance	0.52	0.54
	Interaction: HDD x Dummy: in Garage	2.96	3.23*
	Interaction: CDD x Dummy: in Garage	1.33	1.07
Freezer	Age (years)	19.61	20.74
	Dummy: Unit Manufactured Pre-1990	0.31	0.35
	Size (ft.3)	15.41	15.92
	Dummy: Chest Freezer	0.41	0.41
	Interaction: CDD x Dummy: in Garage	1.87	1.88*
	Interaction: HDD x Dummy: in Garage	4.16	5.27

Note that HDDs were not included in the PY10 model specification.

Table 9 compares the PY10 and PY11 UEC directly which, as mentioned above, declined slightly for refrigerators and increased slightly for freezers.

Table 9. Comparison of PY10 and PY11 UECs

Appliance	Per-Unit Average UEC	
	PY10	PY11
Refrigerators	1,097	1,032
Freezers	791	805

4.2 Part-Use

"Part-use" is an adjustment factor specific to appliance recycling that is used to convert the UEC into an average per-unit gross savings value. The UEC itself is not equal to the gross savings value, because:

- The UEC model yields an estimate of annual consumption.
- Not all recycled refrigerators would have operated year-round had they not been decommissioned through the program.

Because Cadmus applied UMP's methodology, the determination of PY11 part-use is slightly different than PY10. Specifically, in the PY10 evaluation, we assumed that how customers operated participating appliances prior to the program

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was a reasonable proxy for how the same appliances were likely to be operated in the future had they not been recycled through ARP (either by the participant or, if the appliance was transferred, by the would-be recipient).

While the UMP part-use methodology still uses information from surveyed customers regarding pre-program usage patterns, the final estimate of part-use reflects how appliances were likely to operate had they not been recycled (not how they previously operated). For example, it is possible that a primary refrigerator operated year-round would have become a secondary appliance and been operated part-time.

The updated methodology accounts for these potential shifts in usage types. Specifically, part-use is calculated using a weighted average of the following prospective part-use categories and factors:

- Appliances that would have run full-time (part-use = 1.0)
- Appliances that would not have run at all (part-use = 0.0)
- Appliances that would have operated a portion of the year (part-use is between 0.0 and 1.0)

Using information gathered through the participant survey, Cadmus undertook the following multi-step process to determine part-use as outlined in UMP.

1. We determined if recycled refrigerators were primary or secondary units. (All stand-alone freezers are considered secondary units.)

2. We asked those participants who indicated they had recycled a secondary refrigerator if the refrigerator was unplugged, operated year-round, or operated for a portion of the preceding year. (We assume all primary units were operated year-round.) We posed the same question all freezer participants.

3. We asked those participants who indicated that their secondary refrigerator or freezer was operated for only a portion of the preceding year to estimate the total number of months during that time the appliance was plugged in. The average number of months specified by this subset of participant was 3.3 and 4.3 for secondary refrigerators and freezers, respectively. We then divided both values by 12 to calculate the annual part-use factor for all secondary refrigerators and freezers operated for only a portion of the year. For PY11, the average secondary refrigerator and freezer operating part-time was determined to have a part-use factor of 0.28 and 0.35, respectively.

These three steps resulted in the following information about how refrigerators and freezers were operated prior to recycling (Table 10).

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Table 10. Part-Use Factors and Adjusted Energy Savings by Appliance and Usage Type

Usage Type and Part-Use Category	Refrigerators			Freezers		
	Percent of Recycled Units	Part-Use Factor	Per-Unit Energy Savings (kWh/Year)	Percent of Recycled Units	Part-Use Factor	Per-Unit Energy Savings (kWh/Year)
Secondary Units Only						
Not in Use	8%	0	-	NA	NA	NA
Used Part Time	14%	0.35	365	NA	NA	NA
Used Full Time	78%	1.00	1031	NA	NA	NA
Weighted Average	100%	0.83	854	NA	NA	NA
All Units (Primary and Secondary)						
Not in Use	4%	0	-	2%	0	-
Used Part Time	8%	0.35	365	7%	0.28	232
Used Full Time	88%	1.00	1031	91%	1.00	834
Weighted Average	100%	0.91	938	100%	0.93	777

For participants who indicated that they would have kept their unit and who did not replace their unit, it is assumed that they would have used their unit in the same manner they had historically.

For appliances that would have stayed within the participating home in the program's absence but survey respondents also indicated they replaced their unit, the team assumed the recycled unit would have been kept as a secondary appliance (5%). In such cases, the part-use factor for secondary units was applied as there was no clear way to know how participants would have used the units.

Participants who indicated they would have discarded their appliance independent of ARP were not asked a similar question (as the future usage of that appliance would be determined by another customer). Since the future usage type of discarded refrigerators is unknown, Cadmus applied the weighted part-use average of all units (0.91) for all refrigerators that would have been discarded independent of the program. This approach acknowledges that discarded appliances might be used as primary or secondary units in the would-be recipient's home.

Combining the historically based part-use factors in Table 10 with participants' self-reported action had the program not been available resulted in the following distribution of likely future usage scenarios and corresponding part-use estimates. The weighted average of these future scenarios, shown in Table 11, produces ARP's PY11 part-use factor for refrigerators (0.90) and freezers (0.93).

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Table 11. Part-Use Factors

Use Prior to Recycling	Likely Use Independent of Recycling	Refrigerator		Freezer	
		Part-Use Factor	Percent of Participants	Part-Use Factor	Percent of Participants
Primary	Kept (as primary unit)	1	0%	NA	NA
	Kept (as secondary unit)	0.83	5%	NA	NA
	Discarded	0.91	45%	NA	NA
Secondary	Kept	0.83	7%	0.93	13%
	Discarded	0.91	43%	0.93	87%
Overall	All	0.90	100%	0.93	100%

After the first program year (PY10), freezers' part-use factors increased from 0.84 to 0.93. Though higher than other similarly mature programs (see Table 12), this trends in the direction expected. Prior to implementation of a recycling program, many unused or partially used appliances commonly sit idle in customers' homes, as they have no means of discarding them. Implementation of PEC's program provides the opportunity many of these customers need for discarding of unwanted appliances. Over time, as the program achieves greater market penetration, the pool of unused, unwanted appliances lingering in customer households shrinks. Consequently, recycling programs typically collect increasing numbers of appliances operating year-round, experiencing increases in evaluated part-use factors, and thus verified energy savings.

The part-use factor for refrigerators declined from 0.98 to 0.90 in PY11. The decline, while contrary to the reasoning outlined above, is not unexpected as the part-use estimate for PEC from PY10 was atypically high. Again, Table 12 below compares PEC's part-use to other programs of comparably mature programs.

In addition, the application of prospective part-use outlined above also accounts for some of the decrease between PY10 and PY11 for refrigerators.

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Table 12. Benchmarking: Part-Use

Utility	Years Implemented	Refrigerators	Freezers
PEC (PY10)	1	0.98	0.84
PEC (PY11)	2	0.90	0.93
Avista*	4	0.94	0.82
Ontario Power Authority**	4	0.90	0.89
PacifiCorp (Washington)***	5	0.93	0.89

* http://www.nwcouncil.org/energy/rtf/subcommittees/fridgerecycle/Avista%202010-2011%20Electric%20Impact%20Report_FINAL.pdf

**http://www.powerauthority.on.ca/sites/default/files/new_files/2010/2010%20Residential%20Great%20Refrigerator%20Roundup%20Program%20Evaluation.pdf

*** http://www.nwcouncil.org/energy/rtf/subcommittees/fridgerecycle/pacificorp%20wa%202009-10%20rrp%20final%20emv%20cadmus%2020120106.pdf

Notes:
- Differences in part-use factors for both refrigerators and freezers between PY11 and PY10 were not statistically significant at 90% confidence
- All benchmarked studies were conducted prior to UMP (i.e., part-use was based on historical usage, similar to PEC PY10)

4.3 Gross Savings

Applying the above part-use factors to modeled annual consumption from Table 7 yielded PEC's PY11 average per-unit gross energy savings. As shown in Table 13, PY11 verified per-unit values for refrigerators and freezers were determined at 929 kWh and 749kWh.

Table 13. Evaluated Gross Energy Savings (Per-Unit)

Appliance	Average UEC (kWh/Year)	Gross Demand Reduction (kW)	Part-Use Factor	Gross Energy Savings (kWh/Year)	Gross Demand Reduction (kW)	Precision at 90% Confidence*
Refrigerators	1,032	0.12	0.90	929	0.11	± 10.9%
Freezers	805	0.09	0.93	749	0.09	± 24.5%

* Precision is calculated to reflect the combined effect of error, generated by the regression model and the survey-based part-use estimate.

Table 14 compares PY11 per-unit deemed and verified energy savings. As shown, verified refrigerator savings (929 kWh/year) fell below last year's evaluation result (1,073 kWh/year). The decline is partially due to the changes in the model outlined above (additional data and altered specification), as well as the decline in the part-use. Since the part-use factor is applied directly to the UEC, the decrease from 0.98 to 0.90 results in an eight percent decrease in gross energy savings. However, verified energy savings for freezers (749kWh/year) were higher than the freezer deemed savings value (668 kWh/year).

Table 14. Comparison of Per-Unit Gross Deemed and Verified Savings

	Per-Unit Gross Energy Savings (kWh/Year)		
Appliance	Deemed	Verified	Realization Rate
Refrigerators	1,073	929	87%
Freezers	668	749	112%

4.4 Replacement

In most cases, the per-unit gross energy savings attributable to the program is equal to the energy consumption of the recycled appliance, rather than being equal to the difference between the consumption of the participating appliance and its replacement (when applicable). This is because the energy savings generated by the program are not limited to the change within the participant's home, but rather to the change in energy consumption at the grid-level.

UMP states that evaluators must account for the energy consumption of replacement units *only* when the program induces the replacement (i.e., when the participant would *not* have purchased the replacement refrigerator in the absence of the recycling program). In the case of non-induced replacements, the energy consumption of the replacement appliance is not germane to the savings analysis since that appliance would have been purchased or acquired regardless of program. It is critical to note that the acquisition of another appliance in conjunction with participation in ARP does not necessarily indicate induced replacement.

This concept is best explained with an example. Suppose a customer decides to purchase a new refrigerator to replace an existing one. When the customer mentions this to a neighbor, the neighbor asks for their existing refrigerator, which they plan to use as a secondary unit for themselves. The customer agrees to give their old appliance to the neighbor. However, before this transfer is made, the customer learns about a utility-sponsored appliance recycling program, and decides to participate since the incentive helps offsets the cost of the new refrigerator. As a result of program intervention, the customer's appliance is permanently removed from operation in the utility's service territory.

From the utility's perspective, the difference in grid-level energy consumption—and the corresponding increase in program savings—is equal to the consumption of the recycled appliance, and not to the difference between the participating appliance and its replacement. It is also important to note in this example that the participant planned to replace the appliance. In general, the purchase of new refrigerators is part of the naturally occurring appliance lifecycle, generally independent of the program[10], and tantamount to refrigerator load growth. It is not the purpose of the program to prevent these inevitable purchases, but rather to minimize the grid-level refrigerator load growth by limiting the number of appliances that continue to operate once they are replaced.

However, when a recycling program induces replacement (i.e., the participant would not have purchased the new refrigerator in absence of the recycling program), evaluators must account for replacement. The methodology for determining induced replacement is discussed in detail in section 4.10 Induced Replacement.

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[10] With the exception of induced replacement, which is addressed below.

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4.5 Facility Audit

The program tracking system's audit was undertaken to assess the accuracy of data maintained within ARCA's PY11 database and to determine whether any errors occurred that might result in incorrect reporting of program accomplishments.

Between May 8 and June 5, 2012, an evaluation team engineer audited the ARCA recycling facility in Morrisville, North Carolina on five occasions. During each visit, the engineer selected a random sample of units waiting to be decommissioned. In all, 216 appliances were assessed and compared to records stored in the program's tracking system for 2012.

However, the evaluation team was not aware that the Morrisville facility also recycles units for other programs. As a result, nearly half of the units (101) that the engineer assessed did not match the ARCA data extract for Progress Energy. The evaluation team requested additional data from ARCA for the other units but, due to confidentiality concerns, the team was not able to obtain the data. The units that did not match were thus excluded from the analysis and the sample of units declined. The sample remained sufficient as 112 units were successfully matched with the ARCA tracking data.

The auditor physically inspected each sampled appliance (including physically measuring the appliance's size prior to disassembly), independently assessed its characteristics, and then compared the assessment to information contained in the program database. All information gathered for the sampled appliances was recorded electronically using a customized spreadsheet.

Specifically, the auditor collected the following appliance characteristics:

- ATO number
- Manufacturer
- Configuration
- Age
- Size

This information, as shown in previous evaluations, is critical to assessing energy consumption, and errors can lead to inaccurate estimated energy savings. The results of the facility audit are as follows:

- *ATO number:* A unit's ATO number, the appliance's primary identifier for both implementation and evaluation purposes, is automatically generated when an appointment is booked, and then used to track a specific appliance from the beginning of the process (when booking the appliance pickup) through decommissioning.

  Each sampled appliance had very legible ATO numbers written on its door and side, indicating drivers followed the identified process of physically writing the ATO number on the appliances.

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- *Manufacturer:* The data ARCA provided did not include the manufacturer so there was no possibility of comparison between the data collected by the auditor and the ARCA data. However, the manufacturer data was used to help verify the appliance age, as outlined below.

- *Configuration:* There were no discrepancies between configurations in the ARCA database and the audit data.

- *Size:* Discrepancies were minimal between the ARCA data and the auditor's data, and likely the result of rounding.

- *Age:* Due to the difficulty often associated with determining an appliance's age, the auditor followed a multistep process to determine each sampled appliance's year of manufacture and, therefore, its age:

  1. Recording the date of manufacture on the nameplate of the unit when explicitly stated.

  2. Using a website[11] that provides the date of manufacture for many brands, from the model and serial numbers of the unit.

  3. Telephoning manufacturers[12] to obtain the date of manufacture from the model and serial numbers. In some cases, the manufacturers could only provide multiple dates, not a unique one, because of the re-use of model numbers.

  Even using these steps, it can be difficult to confidently determine a specific age for some appliances. The evaluation team recognizes this difficulty and agrees tracking appliance ages using ranges acknowledges this inherent uncertainty and allows ARCA some discretion in determining an appliance's age.

  Age was the category of the most concern after the PY10 evaluation due to its substantial impact on unit savings estimates. This time, after collecting the on-site data and comparing the ages to the data collected by ARCA, the auditor again found minimal discrepancies. The mean age determined by the auditor was 16.2 years, and the mean appliance age determined by ARCA was 16.9 years with an average difference of only 2 percent.

The audit supports the accuracy of the data collected in the ARCA database. The units recycled through PEC's program appear to be younger than units in other programs of comparable maturity on average.[13]

4.6   Summary of Verified Gross Program Impacts

To determine the program's total verified gross impacts, the per-unit energy savings values shown above were applied, by appliance, to the PY11 population. These results are shown in Table 15.

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[11] www.appliance411.com
[12] Manufacturers telephoned included: General Electric, Whirlpool, Hotpoint, Amana, Frigidaire, and Kenmore.
[13] A comparison of ages for various recycling programs was provided in the PY10 report. It is also important to note facility audits are not conducted as part of all recycling evaluations so the characteristics of unit recycled through other programs may not have been independently verified.

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Table 15. PY11 Verified Gross Program Savings

Appliance	Average Per-Unit Gross Energy Savings (kWh/Year)	Average Per-Unit Gross Demand Reduction (kW/Year)	PY11 Participation	Total Program Gross Savings (MWh/Year)	Total Gross Demand Reduction (MW/Year)	Precision at 90% Confidence
Refrigerator	929	0.106	5,879	5,460	0.62	± 10.9%
Freezer	749	0.085	1,663	1,245	0.14	± 24.5%
Total			7,542	6,705	0.77	± 13.9%

4.7 Determination of Net Savings

This section details Cadmus' determination of net savings. In the case of appliance recycling, programs only generate net savings when the recycled appliance would have continued to operate absent program intervention (either within the participating customer's home or at the home of another utility customer).

The application of the UMP protocol introduced two parameters related to net savings—secondary market impacts and induced replacement—that were not included in the PY10 evaluation. In addition, UMP employs a decision-tree approach to calculate and present net program savings. Again, this approach represents a departure from PY10.

The decision tree—populated by the responses of surveyed PY11 participants and information gathered from interviewed market actors—presents all of the program's possible savings scenarios. We used a weighted average of these scenarios to calculate the net savings attributable to ARP. We provide specific portions of the decision tree throughout this chapter to highlight specific aspects of our net savings analysis. We have also provided the entire decision tree in Appendix A (refrigerators) and B (freezers).

Unlike PY10, the decision tree accounts not only for what the participating household would have done independent of the program but also for the possibility that the unit would transferred to another household, and whether or not the would-be acquirer of that refrigerator finds an alternate unit instead.

4.8 Free Ridership

In general, independent of program intervention, participating refrigerators would have been subject to one of the following scenarios:

1. The refrigerator would have been kept by the household.

2. The refrigerator would have been discarded by a method that transfers it to another customer for continued use.

3. The refrigerator would have been discarded by a method leading to its removal from service.

Free ridership would occur under Scenario 3 since units would have been removed from the grid and destroyed, even though not recycled through the program. As a result, the program could not claim energy savings generated by recycling these appliances.

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To determine the percentage of participants in each of the scenarios, therefore assessing the program's free ridership, each surveyed participant was asked the likely fate of the participating appliance, had it not been recycled by PEC. Responses provided by participants included the following hypothetical actions:

- Kept it and continued to operate the appliance.

- Kept it but stored it unplugged indefinitely.

- Sold it to a private party, either by running an ad or to someone you know.

- Sold it to a used appliance dealer.

- Given it away to a private party, such as a friend or neighbor.

- Given it away to a charity organization, such as Goodwill Industries or a church.

- Had it removed by the dealer from whom you got your new or replacement appliance?

- Hauled it to the dump or recycling center yourself.

- Hired someone else to haul it away for junking or dumping.[14]

To ensure the highest quality of responses possible and to attempt to mitigate a socially responsible response bias, some participants were asked follow-up questions, based on the response provided, to test the reliability of the participant's initial response. For example, through our interviews with local market actors in PY10, we determined that used appliance dealers are unlikely to purchase appliances more than 10 years old.

We then asked any surveyed participants with an appliance more than 10 years old who indicated they "would have sold their unit to a used appliance dealer" what they would have likely done *had they been unable to sell the unit to a dealer.* Using their responses to this subsequent question, we then could assess free ridership. This dynamic, market research-based approach to surveying improves the reliability of the hypothetical self-reported actions of participants.

Upon validating the participant's hypothetical action (in the absence of Progress Energy's program) to the extent possible through the described iterative approach, the evaluation team assessed whether each participant's response indicated free ridership. Some responses clearly indicated free ridership (i.e., "I would have taken it to the dump or recycling center myself"). Other responses clearly did not indicate free ridership as the appliance would have remained active within the participating home (i.e., "I would have kept it") or elsewhere within Progress Energy's service territory (i.e., "I would have given it to a family member, neighbor, or friend").

However, some responses—such as "I would have sold it to a used appliance dealer"—proved less clear regarding free ridership. To determine if responses were indicative of free ridership, the evaluation team had to determine whether a used appliance dealer would actually be interested in purchasing the appliance. As used appliance dealers could not be asked their interest in a specific appliance, interviews with such market actors were conducted in PY10, to establish general characteristics (e.g., age, condition, features) of older appliances viable for resale on the secondary market within Progress

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[14] Transfer stations in North Carolina do not require coolant removal prior to disposing of a unit according to Waste Industries USA, Inc,

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Energy's service territory. With this information, the evaluation team could validate or invalidate a participant's response, based on specific characteristics of appliances they recycled. The consensus was that used appliance dealers rarely purchase units that are older than 10 year in age to resell.

Another ambiguous response was: "I would have it removed by the dealer who sold me my new appliance." To categorize such responses, the evaluation team had to determine what new and used retailers did with the appliances collected when delivering a new or replacement appliance. Again, the PY10 interviews with local market actors provided insights into whether appliances collected independently of the ARP were resold (directly or indirectly) or destroyed.

To inform the NTG analysis, the market actor interview findings from PY10 were used to categorize free rider scores based on the unit's age, specifically units that were older than 10 years and were thus determined to be unviable on the secondary market. Table 16 summarizes results, as related to assessing NTG, for each participant response requiring market information for validation.

Table 16. Summary of Free Ridership-Related Market Actor Interviews Findings

Hypothetical Action Absent Program	Free ridership Assessment	Detail
I would have sold it to a used appliance dealer.	Varies by Appliance Age	If the responding participant's appliance is less than 10 years old, the appliance will not be categorized as a free rider (as the appliance likely has resale value). If the appliance is older than 10 years old, the free ridership analysis relied on other methods of disposal that the respondent gave serious consideration to.
I would have it removed by the dealer, who sold me my new appliance.	Varies by Retailer Type and Appliance Age	All appliances collected by national retailers were categorized as free-riders (as they are destroyed regardless of age). For appliances older than 10 years that would have been collected by used appliance dealers the free ridership analysis also relied on other methods of disposal that the respondent gave serious consideration to.

Based on information provided from surveyed participants and interviewed market actors, the evaluation team determined the discard scenario absent the program.

After determining discard scenarios based on the participant surveys, the evaluation team used a similar methodology to determine discard scenarios as reported by surveyed nonparticipants. The nonparticipant determination was based on nonparticipants' actual disposal actions (as opposed to the hypothetical actions offered by participants).

To determine overall discard scenarios, the evaluation team averaged the ratios for participating and nonparticipating respondents using the inverse variance[15] as a weight for each estimate, shown in Table 17. Calculating the average using inverse variance weights ensures greater weight is placed on values with a higher degree of certainty.

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[15] Inverse-variance weighting is a method of aggregating two or more variables to minimize the variance of the sum.

Table 17. Participant and Nonparticipant Discard Scenarios Survey Results

Appliance	Discard/Transfer Scenario	Participant Survey Percent	Nonparticipant Survey Percent	Inverse Variance Weighted Average
Refrigerator	Disposed	43%	38%	40%
	Transfer	57%	63%	60%
Freezer	Disposed	26%	18%	22%
	Transfer	74%	82%	78%

Once Cadmus determined the final assessments of participants' actions independent of ARP, we calculated the percent of refrigerators and freezers that would have been kept (Table 18).

Table 18. Distribution of Kept and Discarded Appliance

Stated Action Absent Program	Indicative of Free ridership	Refrigerators (n=148)	Freezers (n=47)
Kept	No	26%	33%
Discarded	Varies by Discard Method	74%	67%
Total		100%	100%

As evident in Table 19, the percent of PEC's participants (in both PY10 and PY11) who stated they would have kept their appliance in the absence of the ARP is considerably higher than the three benchmarked programs. Factors contributing to the difference likely include ARCA's target marketing strategies and the somewhat more mature programs against which PEC is being compared.

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Table 19. Benchmarking Kept and Discarded Scenarios

Utility	Years Implemented	Percent Likely To Have Been Kept Independent of the Program	
		Refrigerators	Freezers
PEC (PY10)	1	37%	40%
PEC (PY11)	2	26%	33%
Avista†	4	17%	17%
Ontario Power Authority**†	4	7.3%	9.5%
PacifiCorp (Washington)†	5	20%	20%

**http://www.powerauthority.on.ca/sites/default/files/new_files/2009/2009%20Residential%20Great%20Refrigerator%20Roundup%20Program%20Evaluation.pdf (The more recent 2010 evaluation cited previously relied on the NTG analysis from this 2009 evaluation).
†All three programs accept primary and secondary refrigerators.

4.9 Secondary Market Impacts

If it is determined that the participant would have directly or indirectly (through a market actor) transferred the unit to another customer on the grid, the next question addresses what that potential acquirer did since that unit was unavailable. There are three possibilities:

A. *None of the would-be acquirers would find another unit.* That is, program participation would result in a one-for-one reduction in the total number of refrigerators operating on the grid. In this case, the total energy consumption of avoided transfers (participating appliances that otherwise would have been used by another customer) should be credited as savings to the program. This position is consistent with the theory that participating appliances are essentially convenience goods for would-be acquirers. (That is, the potential acquirer would have accepted the refrigerator had it been readily available, but since the refrigerator was not a necessity, and the potential acquirer would not seek out an alternate unit.)

B. *All of the would-be acquirers would find another unit.* Thus, program participation has no effect on the total number of refrigerators operating on the grid. This position is consistent with the notion that participating appliances are necessities and that customers will always seek alternative units when participating appliances are unavailable.

C. *Some of would-be acquirers would find another unit, while others would not.* This possibility reflects the awareness that some acquirers were in the market for a refrigerator and would acquire another unit, while others were not (and would only have taken the unit opportunistically).

Because of budget limitations and difficulties in finding data to support would-be acquirers potential actions in order to determine which of the above scenarios applies the evaluation team assumes scenario C – specifically half of the would-be acquirers of avoided transfers found an alternate unit (the midpoint of A and B above). This assumption is consistent with the recommendation of the UMP for when these data are not available.

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Once the proportion of would-be acquirers assumed to find alternate units is established, the next question is whether the alternate unit was likely to be another used appliance (similar to those recycled through the program) or, with fewer used appliances presumably available in the market due to program activity, would the customer acquire a new standard-efficiency unit instead. It is also possible the would-be acquirer of a program unit would select a new ENERGY STAR unit as an alternate, however it seems most likely a customer in the market for a used appliance would upgrade to the new lowest price point. For the reasons previously discussed, the evaluation team again assumes a midpoint approach: half (0.5) of the would-be acquirers of program units would find a similar, used appliance and half (0.5) would acquire a new, standard-efficiency unit.[16]

As evident in Figure 7, accounting for market effects results in three savings scenarios: full savings (i.e., per-unit gross savings), no savings, and partial savings (i.e., the difference between the energy consumption of the program unit and the new, standard-efficiency appliance acquired instead).

Figure 7. Secondary Market Impacts
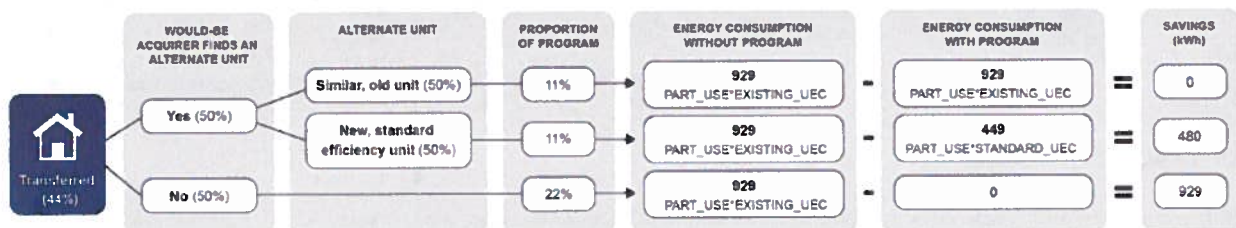
Once the parameters of the free ridership and secondary market impacts are estimated, the evaluation team used the UMP decision tree to calculate the average per-unit program savings net of their combined effect. Figure 8 shows how these values are integrated into a combined estimate of savings net of free ridership and secondary market impacts. Again, the application of secondary market impacts is the result of UMP and was not accounted for in previous ARP evaluations.

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[16] Energy consumption of a new, standard-efficiency appliance was calculated using the ENERGY STAR Website (http://www.energystar.gov/index.cfm?fuseaction=refrig.calculator) taking the average energy consumption of new comparably sized, standard-efficiency appliances with similar configurations as the program units.

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Figure 8. Free ridership and Secondary Market Impact Decision Tree
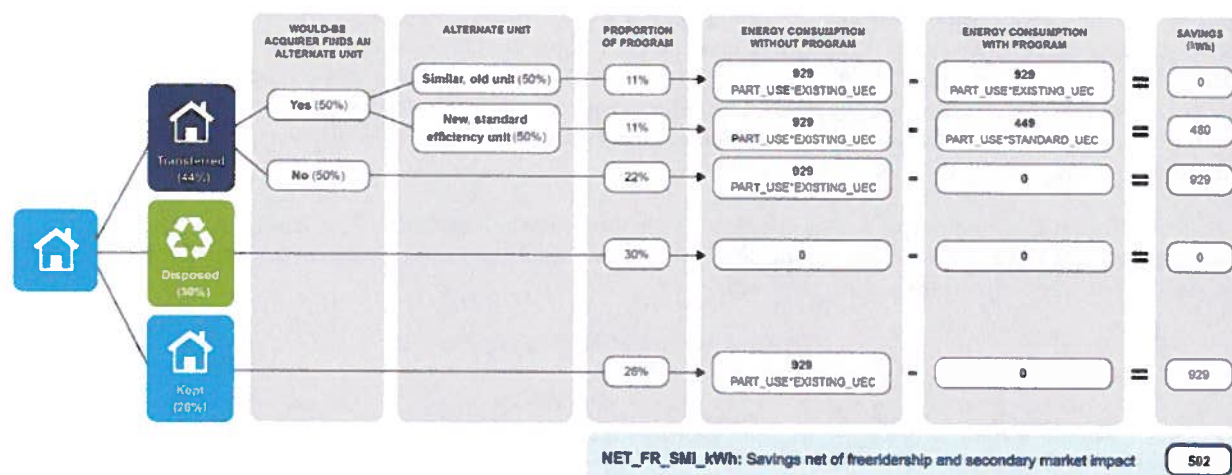
4.10 Induced Replacement

Approximately two-thirds of survey respondents indicated they replaced units they recycled (67%). Given replacement is part of the naturally occurring appliance market, the program should not, in most cases, be held responsible for causing the replacement. In some cases, however, the incentive and free pick-up service provided by PEC sufficiently encouraged participants to purchase a new appliance, which they otherwise would not have. This concept is known as program-induced replacement, and differs from naturally occurring replacement. Therefore, the evaluation team took a nuanced approach to determining instances induced by the program.

If the survey respondent indicated they replaced their unit and they would not have done so without the program, they were asked a follow-up question for clarification: "Just to confirm: you would _not_ have replaced your old appliance without the Progress Energy incentive for recycling, is that correct?" Such questions served as the initial basis for determining program-induced replacement.

To further increase the reliability of these self-reported actions, our induced replacement analysis also considered (1) whether or not the refrigerator was a primary unit and (2) the participant's stated intentions in the absence of the program. For example, if a participant indicated the primary refrigerator would have been discarded independent of the program, it is not possible that the replacement was induced (since it is extremely unlikely the participant would live without a primary refrigerator). However, for all other usage types and stated intention combinations, induced replacement is a viable response.

The induced replacement rates determined for PY11 are shown in Table 20.

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Table 20. PY11 Induced Replacement Rates

| Appliance	Induced Replacement Rates
Refrigerator	1.8%
Freezer	3.4%

Benchmarking induced replacement is difficult as only a small number of evaluations have assessed induced replacement to date. PEC's induced replacement rates for PY11 are provided in Table 21; PEC refrigerators had a slightly lower rate of induced replacement for refrigerators than two recent evaluations in the Pacific Northwest, though the difference is small.

Table 21. Benchmarking Induced Replacement Rates

		Induced Replacement Rates	
Utility	Years Implemented	Refrigerator	Freezer
PEC PY11	2	1.8%	3.4%
Avista*	4	4.1%	4.0%
PacifiCorp (Washington)	5	3.0%	2.9%
*http://www.nwcouncil.org/energy/rtf/subcommittees/fridgerecycle/AVISTA%202011%20NTG%20Report%2012JUN12.pdf			

Once the number of induced replacements was determined, this information was combined with the energy consumption of the replacement appliance obtained from the ENERGY STAR Website. (All induced replacement participants indicated the replacement unit was high-efficiency).

The energy impact of these induced replacements—in per-unit terms—on PY11's net refrigerator savings is shown in Figure 9. As evident in these figures, induced refrigerator replacements resulted in a per-unit increase of 7 kWh for refrigerators.

Figure 9. Refrigerator Induced Consumption

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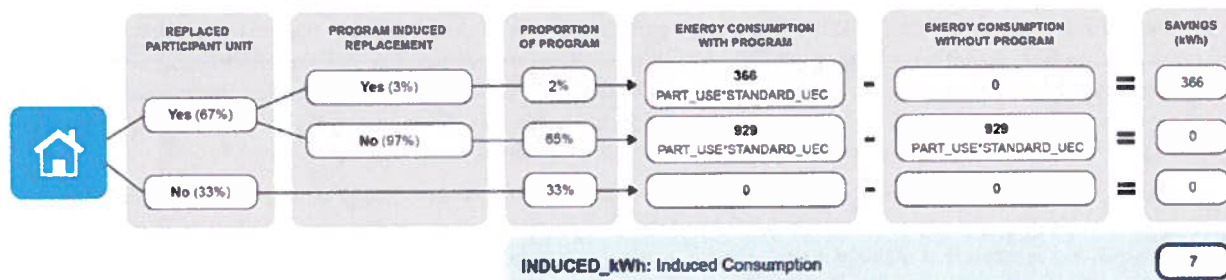
4.11 Spillover

There were 20 (10%) respondents who indicated that they made improvements outside of utility sponsored programs and claimed the ARP was "very influential" on their decision to make improvements. Since multiple responses were allowed, these customers specifically cited 24 non-program efficiency improvements that influenced their participation in PEC's appliance recycling program. As shown in Table 22, the most common responses were CFLs, the addition of insulation, and upgrades to HVAC systems (four mentions each).

Table 22. Spillover Measures Highly Influenced by Program

Spillover Measure	Mentions
CFLs	4
Insulation	4
HVAC	4
ENERGY STAR Dishwasher	3
ENERGY STAR Washer	3
New/Upgraded stove	3
New windows	2
ENERGY STAR Water Heater	1

The improvements cited suggest some level of spillover is occurring. However, the evaluation team does not believe it is possible to quantify spillover associated with these particular responses accurately or that it is prudent to adjust NTG based on the anecdotal mentions of spillover for the following five reasons:

1. *Socially Responsible Response Bias.* While all self-report surveys are subject to socially desirable response bias (for both free ridership and spillover), spillover modules are particularly vulnerable. When provided the opportunity to share non-program energy-efficiency improvements, participants are often quick to recite everything they've done since participating and overly correlate those actions with the program.

2. *Double-counting Savings From Other Programs.* CFLs were mentioned by four participants. However, because of the nature of the upstream program offered by PEC, the savings associated with these CFLs has already been captured in the concurrent lighting program evaluation and should not be double-counted as ARP spillover savings.

3. *Scale of Improvements.* When asked about improvements taken as a result of having their refrigerator or freezer recycled by PEC, half the participants (n=10) noted high-cost improvements. These included replacing windows, upgrading HVAC systems, adding insulation or purchasing an ENERGY STAR water heater. It is unlikely the customer's participation in ARP is primarily responsible given the significant cost of these improvements; as such improvements were likely budgeted in advance of program participation.

4. *Market Shares.* The most commonly cited improvements were energy-efficient appliances such as washing machines and dishwashers (n=6 respondents, total). Many of these appliances reflect a high level of ENERGY STAR market penetration. As a result, it is likely many of these respondents would have purchased a high-efficiency appliance without their experience in ARP. To determine their decision-making process in sufficient detail and attribute these savings to the program definitively, an additional net-to-gross battery of questions would be required for spillover

measures. Such a battery was excluded so as to limit survey length and ensure respondents completed the core survey questions related to ARP.

5. *Difficulty with Quantification.* Additionally, whether a large-scale remodel or an appliance upgrade, the savings generated by participant spillover are difficult to quantify without additional information. Additional information about baseline equipment, usage, and a participant's likeliness to have undertaken the same action independent of ARP would need to be gathered and analyzed. Again, collecting this information as part of the participant survey would add significant length and increase the likelihood of mid-survey drop-offs.

In addition, for measures related to heating or water heating, the evaluation team did not have any information available to determine the heating fuel for the appliance or measure mentioned in order to separate kWh savings from possible therm savings not attributable to PEC. The measures cited as spillover are listed in Table 23 along with the rationale for not applying additional savings.

Table 23. Issues with Spillover Quantification

Spillover Measure	Mentions	Rationale for Not Quantifying Savings
CFLs	4	1, 2
Insulation	4	1, 2, 3, 5
HVAC	4	1, 2, 3, 5
ENERGY STAR Dishwasher	3	1, 4, 5
ENERGY STAR Washer	3	1, 4, 5
New/Upgraded stove	3	1, 5
New windows	2	1, 3, 5
ENERGY STAR Water Heater	1	1, 4, 5

Due to these factors, the evaluation team did not quantify spillover associated with these measures and attribute additional energy savings to the program.

However, the evaluation team did quantify spillover associated with the purchase of ENERGY STAR refrigerator and freezers replacements. While these appliance are also subject to higher ENERGY STAR market penetration rates, the evaluation team's analysis accounts for reported penetration rates. Since these units are the same type of appliance as the program (which offers marketing and education related to the operating cost of refrigerators and freezers) it is more defensible that the program could directly impact the customer's replacement purchasing decision.

The participant survey found that 97% of participants who replaced a refrigerator and 93% of those who replaced a freezer opted for an ENERGY STAR unit. This percentage is substantially higher than the average market penetration rate of ENERGY STAR refrigerators and freezers (56% for refrigerators and 21% for freezers)[17]. Again, the difference can reasonably be attributed to the program as participants learn how much they can save by retiring the inefficient units and replacing them

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[17] http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2011_USD_Summary_Report.pdf

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with an ENERGY STAR rated appliance. Spillover is only calculated for replacements not deemed induced by the program as defined above (including these participants would result in the double counting of ENERGY STAR replacement savings).

Spillover savings are shown for refrigerators (Table 24) and freezers (Table 25) and are calculated as follows:

$$Spillover\ (kWh\ per\ unit) = Replacement\ Rate * (\Delta ENERGY\ STAR\ Rate) * (\Delta kWh)$$

Where:

- *Replacement Rate* = the percent of survey respondents who replaced their appliance
- *ΔENERGY STAR Rate* = Proportion of survey respondents who replaced with ENERGY STAR minus the ENERGY STAR market saturation.
- *ΔkWh* = Annual kWh consumption of a standard efficiency appliance minus the annual kWh consumption of an ENERGY STAR appliance

Table 24. ENERGY STAR Refrigerators Spillover

Appliance	Replaced Appliance		Replaced with ENERGY STAR		ENERGY STAR Market Saturation	Delta kWh	Spillover kWh/ Participating Refrigerator
Refrigerators	Yes	76%	Yes	97%	56%	126	38
			No	3%			
	No	24%					

Table 25. ENERGY STAR Freezer Spillover

Appliance	Replaced Appliance		Replaced with ENERGY STAR		ENERGY STAR Market Saturation	Delta kWh	Spillover kWh/ Participating Freezer
Freezers	Yes	30%	Yes	93%	21%	81	18
			No	7%			
	No	70%					

4.12 Summary of Verified Net Program Impacts

Final NTG is a ratio of total net savings and total gross savings. For PY11 refrigerators had a NTG of 57%, down from 71% in PY10 (prior to the application of UMP principles). Secondary market impacts outlined in UMP also heavily impacted NTG for freezers which lowered NTG from 74% in PY10 to 61% in PY11.

Table 26, summarizes all of the net impacts outlined above and the impact on overall net program savings for PY11. Final, verified net savings are shown in Final NTG is a ratio of total net savings and total gross savings. For PY11 refrigerators had a NTG of 57%, down from 71% in PY10 (prior to the application of UMP principles). Secondary market impacts outlined in UMP also heavily impacted NTG for freezers which lowered NTG from 74% in PY10 to 61% in PY11.

Table 26, which are a result of the following equation:

$$Net\ Program\ Savings\ (MWh\ per\ year) = Gross\ Program\ Savings - FR\ and\ SMI - Induced\ Consumption + Spillover$$

Final NTG is a ratio of total net savings and total gross savings. For PY11 refrigerators had a NTG of 57%, down from 71% in PY10 (prior to the application of UMP principles). Secondary market impacts outlined in UMP also heavily impacted NTG for freezers which lowered NTG from 74% in PY10 to 61% in PY11.

Table 26. PY11 Verified Net Program Savings

| Appliance	Participants	Total Program Gross Savings (MWh/Year)	Free Rider and SMI Impacts (MWh/Year)	Induced Consumption (MWh/Year)	Spillover	Total Program Net Savings (MWh/Year)	NTG
Refrigerator	5,879	5,460	2,510	43	223	3,130	0.57
Freezer	1,663	1,245	473	27	29	774	0.62
Total	7,542	6,705	2,983	70	252	3,904	0.58

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This chapter details process findings drawn from our surveys with participants, and from interviews with PEC and ARCA ARP staff, and regional market actors.

5.1 Key Participant Survey Findings

Participants expressed extremely high satisfaction with the program, with 88 percent rating it a five on a five-point scale. In fact, only two of 184 respondents were less than satisfied. Figure 10 illustrates participants' satisfaction responses.

Figure 10. PY11 Participant Overall Program Satisfaction
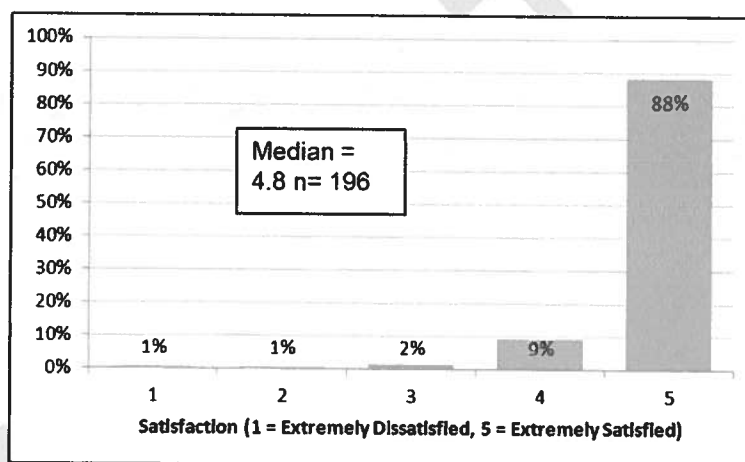
Further, Figure 11 shows that 96 percent of responding participants rated their satisfaction with the amount of time it took to receive their incentive as a four or five on a five-point scale. In addition, 62% said they would have participated at a lower incentive level and 42%said they would have participated in the program even if there were no incentive at all. This indicated participating customers' generally high satisfaction levels with their program experience.

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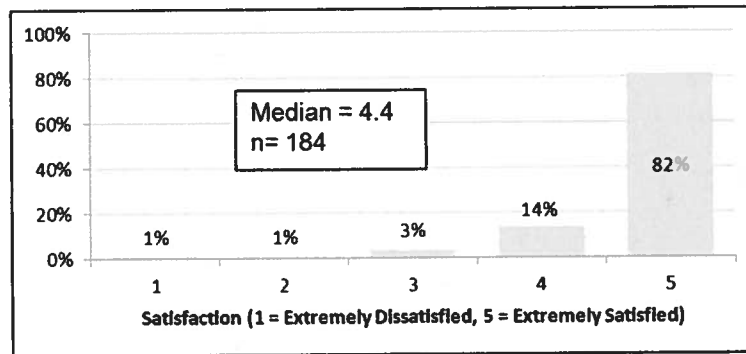**Figure 11. PY11 Participant Satisfaction with Time to Receive Incentive**

Figure 12 shows how participants learned of PEC's program (allowing multiple responses). Participants cited bill inserts (62 percent) and PEC brochures (18 percent), which were not mentioned last year, as the two leading sources of information about the program. Participants also heard about the ARP through referral from friends or family (10 percent), radio, billboards, retailers, PEC representatives, and the PEC website. The results are consistent with marketing efforts that focused on bill inserts, direct mail, and drivers leaving behind information for participants to pass along to friends and family.

Figure 12. PY11 Program Awareness
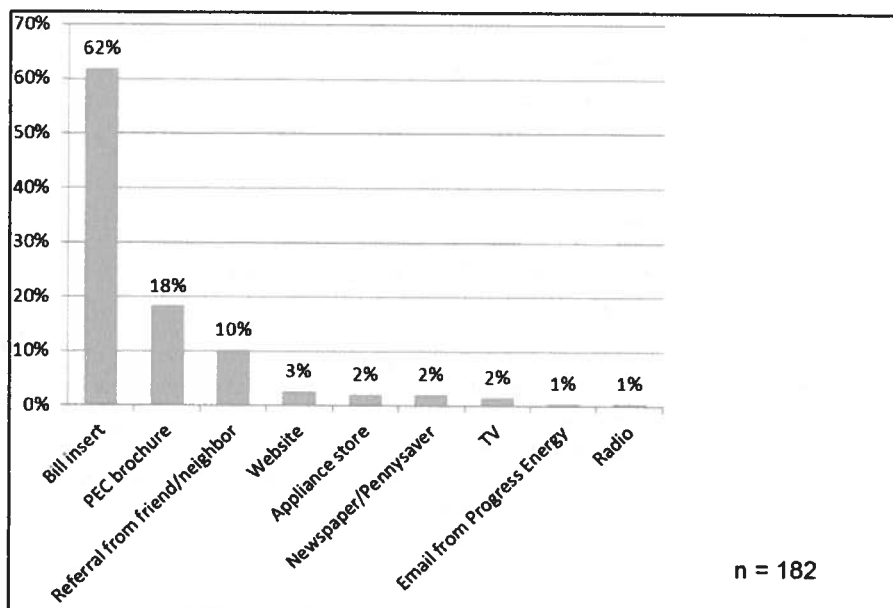
The discussion of gross savings outlined in Section 4.1 , noted that appliance locations play a factor in unit energy consumption. As shown in Figure 13, the majority of refrigerators were located in kitchens (52 percent), while the majority of freezers were located in garages (54 percent). Approximately 57 percent of respondents indicated recycled appliances were located in heated areas, while 55 percent were in air conditioned spaces. The locations remained largely the same as PY10 though there was an increase in the number of freezers kept in the garage (54 vs. 47 percent in PY10).

Figure 13. Location of Recycled Appliance
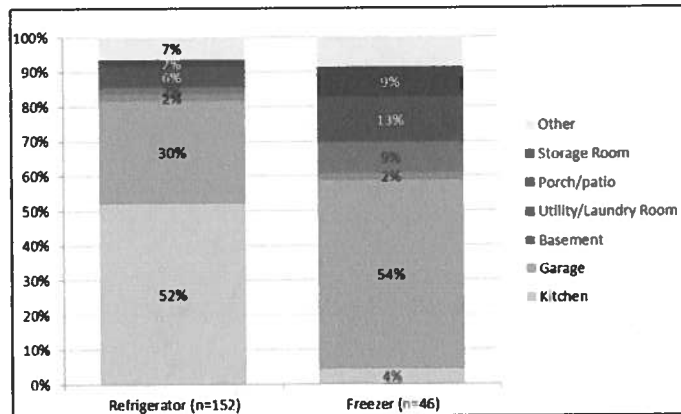
Survey responses showed both the program's rebate and convenience influenced participants' decisions to recycle appliances at the time chosen. Figure 14 shows the respondents' main reasons for recycling their appliances with PEC included the incentive payment received (50 percent), easy and convenient (27 percent), and free pickup (12 percent). Other reasons cited for participating included the program's benefit for the environment, its convenience, and the ARP being the only method the participant knew of.

Figure 14. Main Reason for Choosing Program over Other Disposal Options

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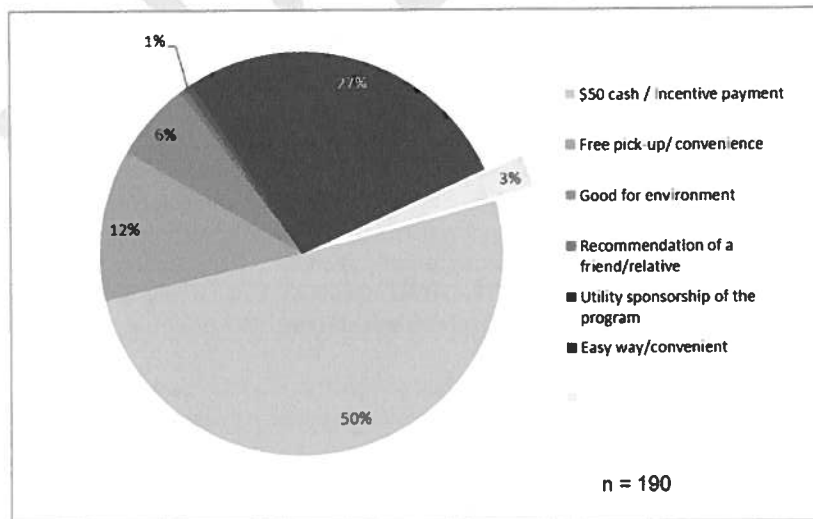
5.2 Key Stakeholder Interview Findings

To better understand how the program evolved in PY11, the evaluation team re-interviewed PEC's program manager and two ARCA managers (whom the evaluation team spoke with as part of the PY10 evaluation). Collectively, these interviews offered insights into possible refinements to the program design, communications amongst program stakeholders, and changes to marketing efforts. The interviews also offered a sense of potential program changes for PY12. Summarized interview findings included the following:

- *Productive project team.* According to all stakeholders, PEC and ARCA continued to maintain an excellent working relationship in PY11.

- *Customer retention.* The cancellation rate has maintained a very low rate, around 2 to 3 percent, well below the program's goal of 5 percent.

- *Regular communication.* All stakeholders reported PEC and ARCA communicated regularly and effectively. Meetings included discussions of marketing concepts, staffing, participation numbers, goals, issues, and invoicing. PEC offered real-time access to a website maintained by ARCA to track numbers of units picked up each day. All stakeholders confirmed communication gaps did not occur between parties.

- *Marketing efforts.* Stakeholders noted bill inserts continued to be the most successful element of the program's annual marketing plan. Bill inserts were utilized four times, the first of which went out in March, to leverage seasonal "spring cleaning" efforts. This specific insert led to PY11's greatest number of participants (see Figure 1). The program manager also mentioned he noticed an increase in calls the beginning of the week immediately after bill inserts went out. Bill messages on the outside of envelopes were also used frequently, as well as email "blasts" and brochures left with participants to hand out to friends and family members. These individual marketing efforts were seen as less effective by program stakeholders but may have collectively helped generate participation.

- *Marketing segmentation.* The program manager mentioned focusing marketing efforts on particular segments of customers using Nielsen PRIZM demographic and market segmentation methodologies. In addition, marketing was targeted to customers who have had the same active account for 15 years or more. This segmentation was intended to target accounts that would likely have older appliances (thereby increasing average per-unit energy savings. Overall, the program manager described PY11 as a "learning year" - specifically learning how to target customer segments more likely to have older, inefficient units. ARCA staff mentioned their marketing department as a resource for the program manager, since ARCA has a wealth of experience marketing ARP programs.

- *Web efforts.* Stakeholders noted that PEC's website has not generated a lot of participation. The program manager mentioned this was likely due to the Web generally appealing to younger people and families.

- *Retailer partnerships.* A partnership with Home Depot incorporating on-site marketing has made up a small portion of participation. The program manager has also talked with Lowes, Sears, and other appliance retailers regarding potential partnership but has not found any other retailers willing to partner. Some retailers also mentioned

developing their own programs. The program manager also mentioned concerns that overemphasizing retailer partnerships could lead to increases in free ridership.

- *Quality control.* During recruiting, ARCA staff followed a provided telephone script, with information gathered uploaded into personal digital assistants for field staff use. ARCA then performed on-the-ground quality assurance. ARCA also trained staff to recognize qualifying units (age, working conditions, etc.) and uploaded this information into the database. At corporate headquarters, all units were subjected to an auditing and invoicing process. If a unit on location did not qualify, field staff explained the situation to the customer, and either left the unit at the house, or disposed of it without charging PEC or providing the customer with an incentive.

- *Incentives and goals.* Stakeholders agreed the incentives were appropriate. Generally, stakeholders described the program as running very smoothly and performing to expectations.

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6.1 Conclusions

Impact

- The program recycled 7,542 units in PY11 (an increase of approximately 16% from PY10), generating 3,904 MWh in net energy savings, (down approximately 15% from PY10).

- ARCA is accurately capturing the ages of participating refrigerators and freezers.

- The refrigerator part-use factor (indicating the portion of the year the average refrigerator would have been operated in the absence of the program) was lower in PY11 (0.90) than PY10 (0.98). Some of the decline is due to the application of prospective part-use outlined in the UMP protocol (rather than the retrospective assessment used in PY10). While subtle methodological differences exist between PY10 and PY11, the primary driver of the lower PY11 part-use value for refrigerators is the fact that fewer survey respondents indicated their appliances were in use year round in PY11 (88%, compared to 97% in PY10). However, the PY11 value is more in line with refrigerator part-use factors found as part of other evaluations. Conversely, the part-use factor for freezers was higher in PY11 (0.93) than PY10 (0.84) and, again, generally consistent with values found through evaluations of similarly aged programs.

- Verified gross per-unit savings for refrigerators (929kWh) were 13% lower than the program's deemed value (1,073 kWh). The disparity was driven largely by the decrease in the part-use factor for refrigerators noted above. Also, the verified gross per-unit savings for freezers (749 kWh) was 12% higher than the program's deemed savings value (668 kWh).

- NTG ratios for both appliance types declined substantially in PY11 (0.57 and 0.62, as opposed to 0.72 and 0.74 in PY10, for refrigerators and freezers, respectively) largely due to changes in NTG methodology between PY10 and PY11 resulting from the UMP protocol.

Process

- There were no major changes in program design in PY11.

- All stakeholders indicated the program operates smoothly, with few complaints and a lower-than-anticipated cancellation rate. Stakeholder perceptions were validated by the high levels of satisfaction reported by surveyed participants (88%) which was comparable to PY10.

- Bill inserts continued to be the most successful marketing tactic in PY11 (cited by 62% of participants as the source of program awareness). Interviewed stakeholders also noted word-of-mouth was becoming an increasing generator of participation, which indicates the program has gained traction within the service territory and been well received by previous participants.

- PY11 marketing was described, by the PEC program manager, as a "learning year" as the program became increasingly aware of how its marketing efforts impacted the program – specifically, how to target customer segments most likely to have older, inefficient units. Marketing segmentation was attempted to reach specific types of
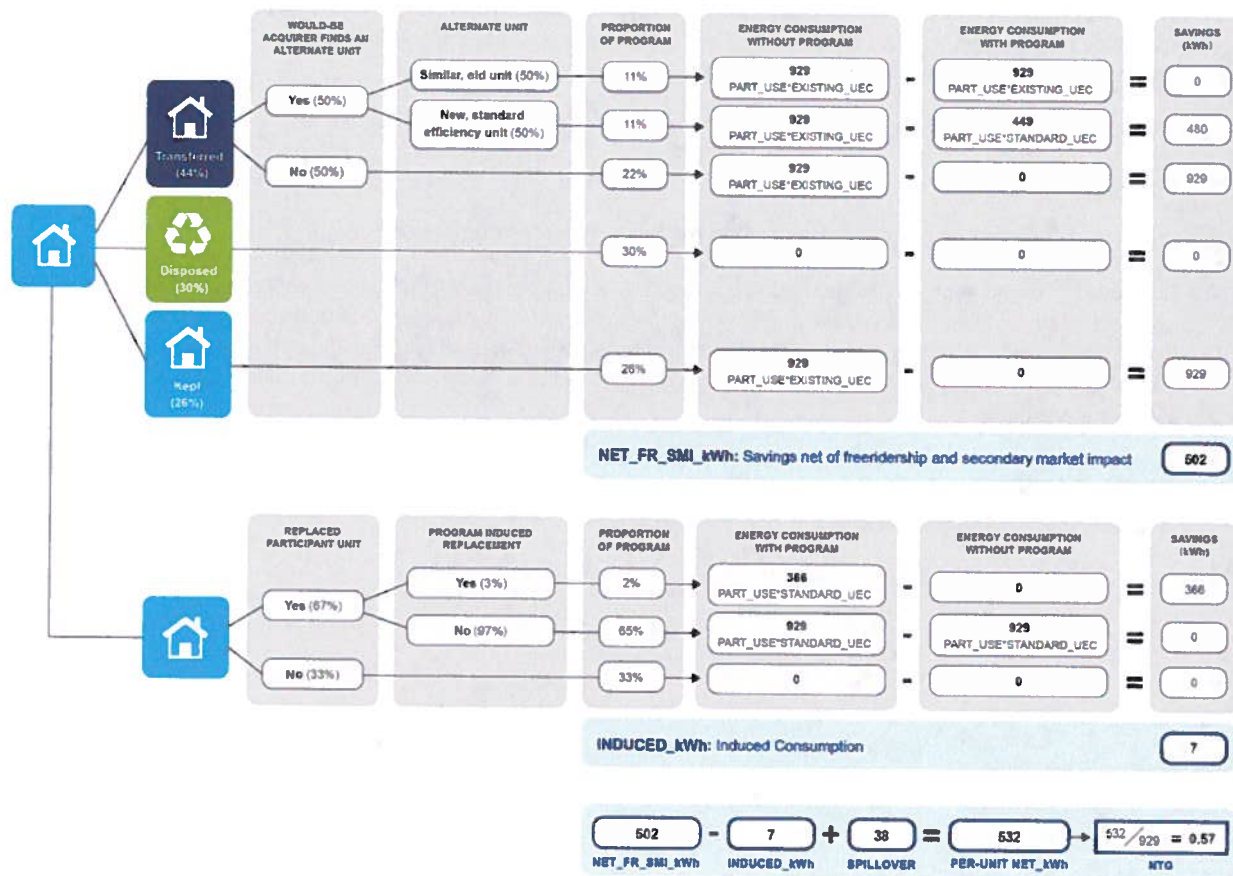
customers, namely established households that are more likely to have older appliances that generate greater savings. The average age for both refrigerators and freezers increased slightly in PY11, both by approximately one year. Since appliance recycling programs typically collected increasingly younger units as they mature, the observed increase in age could be in part due to the marketing efforts.

6.2 Recommendations

Based on these conclusions, the evaluation team offers the following recommendations:

- Continue to employ a myriad of marketing approaches, evaluating the individual and collective effectiveness of each approach on increasing participation and soliciting participation of the targeted customer segments. This could be done by cross checking the average age in the program tracking database by ZIP code with the targeted marketing efforts aimed at identifying areas of PEC's service territory believed to be most likely to own and operate older secondary appliances.

- Work more collaboratively with ARCA to develop a marketing plan that leverages ARCA's extensive experience marketing appliance recycling programs across North America for the purpose of achieving greater market penetration as the program matures.

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Appendix A: NTG Summary - Refrigerators

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Appendix B: NTG Summary - Freezers Summary -

NET_FR_SMI_kWh: Savings net of freeridership and secondary market impact — 473

INDUCED_kWh: Induced Consumption — 16

$$473 - 16 + 18 = 475 \rightarrow \frac{475}{749} = 0.62$$

NET_FR_SMI_kWh − INDUCED_kWh + SPILLOVER = PER-UNIT NET_kWh → NTG